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ABSTRACT

This position paper is written to outline recommendations for a quality science curriculum for schools. Among the recommendations made are that the science curriculum needs to stress excellence; that inquiry approaches are important in helping students to become curious learners who identify problems; that observing natural phenomena in the environment should be the starting point for scientific inquiry; and that emphasis should be placed on the formulation of hypotheses. Sections of the paper deal with recommendations for types of resources that could be used, criticism of state mandated testing, and how to harmonize testing with portfolios. (MM)

The Innovative Science Curriculum

by

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THE INNOVATIVE SCIENCE CURRICULUM

With state mandated testing focusing upon reading and mathematics as the two curriculum areas for annual testing in grades three through eight, as determined by the Elementary and Secondary Education Act (ESEA) beginning with the 2005- 2006 school year, it behooves school officials to emphasize science, also, as a basic. Science is all around us in the natural environment. Science provides knowledge for technological advances and can provide the good things in life. There are also issues in how technology should be used. Thus, drilling for petroleum in wild lie areas, such as in Alaska, has truly become an issue. Science then provides knowledge and skills for advancement in society, but also can be used in a detrimental way. The school curriculum then needs to provide pupils with a quality science curriculum which provides the needed subject matter, skills, and attitudes necessary in a democracy (Ediger, 2000, 10- 12).

Recommendations for a Quality Science Curriculum

The science curriculum needs to meet selected standards in order to stress excellence. Inquiry approaches are highly recommended. Thus, pupil are curious learners and identify problems. Problem identification come about from observing natural phenomenon in the environment. There are questions which then arise in the mind of the learner. The senses of using sight, taste, smell, hearing, and touch are used in learning about natural phenomenon. Observations,too, are extended such as through the use of a microscope.

A science rich classroom setting helps pupils to use the senses and identify problem areas. The author while supervising university student teachers in the public schools noticed classrooms which had one or more of the following:

- * an aquarium in which goldfish were observed carefully by pupils. A question which arose pertained to the goldfish living and swimming in water was, "How can fish live in water while I can't" This question, among others, can be very appropriate to begin inquiry learning.

- * a glass jar containing frog eggs and then developing into tadpoles. The tadpoles then further developed into young adults and placed into a suitable area. Amphibians live part of their life in water and par time on land

- * a terrarium whereby a small garter snake, in a carefully developed setting, was still or moving around cautiously. Pupils

noticed how the reptile generally lived on land, not in water. Pupils while observing the garter snake, asked, "Why does the garter snake hurriedly stick its tongue in and out?"

* a parent brought a caged canary to the classroom. Here, learners noticed and listed distinguishing characteristics of birds. Comparisons were made with fish, amphibians, and reptiles.

* another parent brought to the classroom, for a brief period of time, a mother cat with three small nursing kittens. The concept of mammals was then discussed indepth as to what makes for this category of vertebrates (Ediger and Rao, 1996, Chapter Four).

Once pupils have identified problem areas or questions, about an one animal or category, they are readily to secure information to obtain answers or hypotheses. The hypotheses are tentative and subject to further inquiry for testing purposes. The hypothesis is then revised or accepted as is.

There are a plethora of related learning activities for pupils in studying more about each category of vertebrates. Pupils might brainstorm lists of names for each category of vertebrates. Higher order thinking skills are vital for pupils to develop, such as divergent thought, when branching out to other animals in a vertebrate category. For example, names of birds to branch out a category might include, blue jays, blue birds, sparrows, cardinals, among others. Pictures may be collected or drawn for each species of bird, placed in chart form, and labeled for all to see/review. Classification skills are salient for pupils to develop in science such as classifying fish, amphibians, reptiles, birds, and mammals.

Second, pupils with teacher guidance may make models of each category of vertebrates. Paper mache' models make for attractive visuals. Rules need to be established to make models using paper mache', otherwise it can be a messy activity. A hands on approach in learning is used here.

Third, pupils individually or collectively may do research on a particular vertebrate and present the findings to the total class. For example, a committee of three may research, using a variety of reference sources, the habitat of a member of the reptile family, such as turtles. Turtles with their protective shell do fascinate many pupils. These fascinations may then be explored further with a depth study. Visuals such as collected pictures and drawings may accompany the report given to the class. Communication skills are highly important to develop within

pupils in ongoing lessons and units of study.

Fourth, committees may be developed to read selected library books on a certain facet of vertebrate life such as amphibians. Thus a committee may read and share information on the life cycle on fish. The committee needs to use proper rules for sharing such as all participating and no one dominating the discussion, as well as staying on the topic being pursued.

Fifth, pupils may make a biological chart showing the different Eras of time. These periods of time included

- * Paleozoic with fish coming into being through evolutionary means.

- * Mesozoic with turtles arriving on the scene. Pupils may wish to do some branching out here to include the age of dinosaurs. Birds also came into being in the Mesozoic era with the archaeopteryx.

- * Cenozoic with the development of mammals, including human beings.

The biological chart with the above named Eras may include background scenery to show plant life in relationship to animal life. The dates need to be given for each Era such as the Paleozoic (ancient life), 570 million years to 200 million years ago, approximately. Interesting plants carpeted the earth such as green mosses, ferns, horsetails, club mosses, and seed plants. These plants provided the basis for the coal forests of the Paleozoic era which provided, in time, for conversion from wood to coal formations. Much planning and work go into the development of a biological chart showing the different Eras of plant and animal life. The chart may be a part of an exhibit whereby other classrooms are invited to view the displays. This is an excellent way for all pupils to learn more about science and the interesting activities therein. Much research, effort, and time go into achieving objectives in the science curriculum (See Ediger, 2001, Chapter Four).

Fifth, a quality current events program updates ongoing science lessons and units of study. In the unit on vertebrates, for example, a current events item from Science News (Bower, April 20, 2002), reveals the following:

The evolutionary roots of primates, the group of mammals that gave rise to humans are murky. Paleontologists generally think that the first primates appeared about 65 million years ago, whereas the genetic analyses of the DNA from living primates yield an estimate of 90 million years.

The DNA- derived number comes closer to the mark, according to a research team led by biologist Simon Tavaré of

the University of Southern California in Los Angeles, California. Using a new statistical model of primate evolution the scientists conclude that the older common ancestor of today's primates lived approximately 81.5 million years ago...

The common ancestor of primates, the model suggests, rose before dinosaurs disappeared. The ancestor resembled a modern dwarf lemur, weighing 1 to 2 pounds, and led a nocturnal life in tropical forest, the scientists theorize. Early primates therefore would have expanded northward from tropical areas, rather than originating in northern regions, as many researchers now assume.

A variety of sources need to be used in a science current events program. These include qualified resource persons who communicate well with pupils, internet, world wide web, science magazines written for age and developmentally appropriate pupils, CD ROMS, videos, audio recordings, newspaper articles, among others. Problems and questions may arise from the readings. These need to be clearly stated and information gathered to secure necessary information. Information needs to be evaluated with additional obtained content. The comparisons made make for critical thinking. A resolution among the different information sources involves a synthesis. Creativity in thinking may generally be inherent in working out a synthesis among the data gathered or information acquired. Thus, higher levels of thinking involving critical and creative thinking, as well as problem solving, should be in the offing.

Sixth, reading is an important skill to be used in information gathering. It is not science, in and of itself, but rather a procedure used to secure vital information. Thus, the pupil needs to become proficient in word recognition skills. These include phonics, syllabication, and use of context clues. Word recognition skills are tools, not ends, to use in comprehension of subject matter read. Vital facts, concepts, and generalizations read need to be acquired in comprehension strategies.

The basal science text, library books, among other sources, may well provide content for problem solving. Reading is one way of finding out!

Seventh, experimentation is the heart of the science curriculum. Experiments should involve children in their use. The experiment needs to be performed whereby each participant can observe readily what is going on. Thus, if learners are studying what plants need in order to grow, diverse variables may be evaluated. Two plants from the same/similar stock, properly potted, may be used in the experiment. All variables except one,

need to be held constant. For example, one variable such as the amount of water used for plant growth may be tested for. One potted plant receives a proper amount of water, whereas the adjacent plant does not receive any. One variable then has been tested as to what plants need to survive and grow. Of course, the experiment may be made increasingly complex by having several of the same/similar stock. Each plant is given a different amount of water. In time, children may observe which plant grows best. A line or bar graph may be drawn to show plant growth in comparison with the amount of water received. Other variables to be tested include sunlight versus no sunlight, sandy soil versus loam, as well as different environmental temperature readings for two or more plants. The amount of sunlight may also be tested in terms of degrees as variables (See Ediger, 1994, 24- 25).

Eighth, community service may be integrated into the science curriculum. Clarkin (April 21, 2002) wrote the following pertaining to elementary age pupils in the Hutchinson, Kansas School District planting trees to beautify a section of the Jim P. Martinez nature trail:

The ingredients for creating a living, rose colored ribbon along the bank of the Arkansas River came together Thursday:

- * 50 redbud seedlings
- * about 60 eager school children
- * an assortment of shovels and buckets of water
- * and grownups to help channel good intentions into

finished deeds.

Avenue A elementary School adopted a two mile portion of Hutchinson's Jim P. Martinez Sunflower Trail, which swings through the school's enrollment territory, for cleanup. It's a task tackled a few times during the school year. The Hutchinson Tree Board provided money for purchasing the red bud trees, plus a "song bird bundle" containing trees and shrubs. A forestry technician shows students the proper way to dig a hole and leave enough room to spread the tree's roots out. There are a plethora of possibilities in learning scientific principles in planting trees as well as engaging pupils in a community based beautification project.

Ninth, a multicultural emphasis needs to be stressed in science whereby equality of opportunity is in evidence in the classroom for all pupils. Opportunities to learn stressing equity extends to handicapped pupils. Each pupil needs to experience success in teaching and learning situations as well as achieve optimally. A science curriculum design needs to emphasize a developmental curriculum in which acceptance and belonging

are in evidence. Good attitudes are paramount in developing the science curriculum along with cognitive and psychomotor objectives for pupil attainment.

Tenth, learning by discovery is salient which involves careful, meticulous observation together with making predictions, doing exact measurements of scientific phenomenon, and generalizing on the information gleaned (Ediger, 1995, 14- 15).

There are a plethora of educators who believe that the present emphasis upon state mandated testing might well minimize the importance of science in the curriculum.

State Mandated Testing and the Measurement Movement

State mandated testing addresses concerns which selected educators and lay people have on demonstrated pupil accomplishment and teacher accountability. Thus, state mandated tests are given to indicate what pupils have learned. Generally, a percentile is provided to show where a pupil is in achievement, such as the fiftieth percentile. Weaknesses of state mandated testing, as given by science educators are the following:

- * multiple choice test items cannot measure science processes such as careful observation, problem solving skills, critical and creative thinking, as well as inquiry learning, in contextual situations.

- * multiple choice test items cannot measure quality attitudes toward science.

- * multiple choice test items have emphasized drill in preparing for the state mandated test. Drill is opposite of an inquiry orientated science curriculum.

- * multiple choice test items on reading and mathematics in state mandated tests de-emphasize pupils achieving science objectives and the role of science in the school setting.

Further weaknesses of state mandated tests include the following:

- * these tests lack validity in that pupils in many cases have not been taught that which is covered in the test.

- * the tests may not have been pilot tested before general use was made of them.

- * science may receive short shrift, in practice, if teacher salaries are tied to pupil test results in reading and mathematics. Monetary resources for teaching may then be designated for teaching reading and mathematics (See Jorgenson and

Vanosdall, 2002).

Testing and measurement beliefs are based on realism as a philosophy of education. Realists believe one can know in whole or part the real world as it truly exists and is. For example when looking at chemical formulas, preciseness is in evidence such as in the following: $C_6H_{12}O_6$, the formula for sugar. Thus, 6 atoms of carbon, 12 atoms of hydrogen, and 6 atoms of oxygen make for sugar. The formula is consistent and never varies. Chemistry is precise and accurate. It is true that new elements may be found in the universe, but the number given now is 107 elements and has remained so for sometime. This preciseness and accurateness is then applied to testing pupils to determine what has been learned in the school setting. It is doubtful if the human mind operates in this manner. A pupil's test results may indicate, for example, that he/she is on the fortieth percentile, meaning that out of every 100 pupils, forty are below and sixty above the fortieth percentile. Other precise numerals used to show pupil achievement are standard deviations, and stanines. Sometimes grade equivalents are given, but these are less objective as compared to standard units of measurement such as standard deviations and stanines.

Who writes test items for state mandated tests? Generally it is under the supervision of the state department of education. Human beings do the writing. Usually, they include measurement specialists from a university. Subjectivity is involved here in that other test items could appear on a state mandated test than those chosen by test writers. Readers of literature need to look at a Manual of a standardized test to see how the test items are chosen and how a norm group is selected. The norm group's test results are then used to make comparisons with one's own pupils in the classroom. For example, if a pupil received a score of 45 on a mathematics test, then that score is compared to the norm group in the Manual and may correspond to the fortieth percentile and/or be one standard deviation below the mean. Thus, it is only after the test items have been written, in which subjectivity has been in evidence, that numerals are used to arrive at objectivity as to the precise place where a pupil is in academic achievement. Pupils test results also may indicate "exemplary," "satisfactory," or "needs improvement." These indicators are quite subjective as to where the cut off points are for each of the three levels.

State mandated tests need to be studied, analyzed, and revised to improve the assessment process (See Ediger, 1999, 112- 117).

Harmonizing Testing with Portfolios

Perhaps, a solution may be found in using state mandated test results along with a portfolio approach. Portfolios are quite different in their construction as compared to testing. Portfolios are developed by the pupil himself/herself with teacher guidance, not by external sources as is true of developing state mandated tests. Portfolios emphasize showing the every day classroom work of the student rather than a single numeral indicating achievement on a yearly basis. Thus, a portfolio may include the following representative work of a pupil:

- * essays, biographies, poetry, autobiographies, outlines, summaries, conclusions, among other written work.
- * objects, models, dioramas, construction work, and murals completed by the learner. If the items are too large for a portfolio, snapshots may then be taken for inclusion.
- * illustrations drawn, pencil sketching, water color paintings, among others.
- * audio recordings of reading aloud, talks given, oral book reports, and group discussions, among other oral communication activities.
- * video tapes of creative and formal dramatizations, as well as of pantomiming.
- * self evaluations made in terms of quality criteria.

Portfolios should not become too voluminous, especially since two raters, as a minimum, will assess each on a five point scale. They will reveal actual progress of pupils in listening, speaking, reading, and writing across the curriculum. Interscorer reliability will be a problem when the two raters assess each portfolio. Quality rubrics and their use should help in achieving appropriate reliability.

Test results and portfolio data provide much information on a pupil's progress. Test results provide a numeral for one school year of achievement whereas portfolio endeavors reveal pupil progress from everyday classroom work (See Ediger, 1999, 112-117).

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